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Research Paper

Integrating narrow and wide framing disposition effect: A novel approach incorporating perceived risk and realized asset performance

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ABSTRACT

This paper proposes an integrated framing approach to investigate the disposition effect by linking it to regret and prospect theory. We build upon the wide framing hypothesis and extend prior research by including metrics of perceived risk and the number of days stocks are at a gain. Using a sample of 24 million trading operations conducted by nearly 4,000 Italian investors from 2010 to 2018, we demonstrate that investment decisions are influenced not only by portfolio aggregate performance but also by asset trading history and perceived volatility. Our results align with several theoretical frameworks that could explain the disposition effect, such as mental accounting, prospect theory and regret aversion. Furthermore, by incorporating both narrow and wide framing factors, along with their interactions, our approach provides a more comprehensive understanding of the disposition effect.

1. Introduction

According to Shefrin and Statman (1985), when investors face the decision to modify their portfolio, they tend to sell stocks that have gained value at a higher rate rather than stocks that have lost value. However, this behavior contradicts the rational hypothesis that investors are utility maximizers, as demonstrated by Jegadeesh and Titman (1993). Subsequent research conducted by analyzing diverse financial markets and types of investors has provided evidence of the so-called disposition effect (Odean, 1998). Frazzini (2006) highlighted the implications of the disposition effect on equilibrium price formation, noting that investors who are less willing to sell stocks with negative price histories create an asymmetry between demand and supply.

The literature has generally regarded the disposition effect as a *narrow framing* phenomenon, meaning that it is related to the performance of individual assets rather than the composition of the entire portfolio. More recently, researchers have tried to explain the disposition effect based on a *wide framing* hypothesis (Sakaguchi et al. (2019), Brettschneider et al. (2021a, 2021b), An et al. (2023)), suggesting that investors decide whether to sell a stock after looking at the entire portfolio performance. In recent years, the wide framing approach has gained increasing popularity in financial econometrics thanks to its strong connections with behavioral finance (see Grinblatt and Keloharju (2001), Hartzmark (2015)).

In this paper, we aim to further advance the current stream of research by proposing an integrated framing approach that combines the wide and narrow framing hypotheses. Our approach also considers the aggregate portfolio performance and specific

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dynamics of the assets within it. Specifically, we take into account the volatility of each stock in the portfolio as a measure of the risk of holding a stock, as well as the fraction of days on which stocks are at a gain. By doing so, we can test whether the decision to sell a stock depends on its past performance. This enables us to propose a potential relation between the disposition effect and both prospect theory and regret theory.

We estimate the proposed theoretical model on a dataset of more than 24 million trade transactions executed by nearly 4,000 Italian investors who invested in more than 6,000 distinct assets during the period from January 2010 to December 2018. We test the validity of our original dataset by estimating a baseline model under the wide framing hypothesis as in Brettschneider et al. (2021a, 2021b). Next, we introduce an augmented econometric model that allows us to link our results to both regret and prospect theories. We include our variables that account for the trading history of each stock, aggregate portfolio performance, and holding times, as well as their interactions. This approach allows us to explore the notion that the apprehension of experiencing regret plays an important role in shaping investors' choices to divest from a stock. Furthermore, it facilitates an evaluation of whether investors exhibit heightened risk aversion within the realm of gains, aligning with the predictions set forth by prospect theory. Importantly, we test our integrated framework approach on real trading data without relying on computer simulations or imposing constraints on the representative investor's rationality. Our findings align with the outcomes observed in Jegadeesh and Titman (1993) and Barberis and Xiong (2009), indicating that investors' aversion to regret may potentially mitigate the disposition effect. This influence is evident in their varying propensities to sell stocks at a gain versus those at a loss. Indeed, our results indicate that investors tend to sidestep the anticipation of future regrets by divesting from assets that, despite past positive performance, are currently in a downturn. Furthermore, there is a preference to retain assets that have demonstrated past success and are currently yielding gains. Moreover, the proposed integrated approach likely reconciles the narrow framing approach with the curvature of the investors' value function postulated by the prospect theory i.e. the effect of asset volatility on the propensity to sell is more pronounced for stocks at a gain. The asymmetry we estimate between the willingness to sell losses and gains through our approach seems to align more coherently with the parameters of the value function compared to the asymmetry identified in prior literature (Barberis and Xiong, 2009; Kaustia, 2010). Finally, our empirical findings are also consistent with other theoretical framework that may explain the disposition effect.

The paper is organized as follows. In section 2, we thoroughly review the existing literature, from the initial works in the field to the recent research closest to our investigation. In Section 3, we detail the dataset we use, the models we propose, the statistical procedure we follow, and the relevant theory. Section 4 presents and explains our results, which we link with regret and prospect theories. Lastly, in Section 5, we provide some concluding remarks.

2. Literature review

The disposition effect is a relevant topic in the economics of financial markets since, through its consequences, it influences the process of equilibrium price formation (Frazzini, 2006). Its relationship with the momentum of stock returns has gained growing attention over the years. Grinblatt and Han (2005) developed a model with two types of investors in random proportion: disposition investors and rational investors. They found that the return momentum can depend on this proportion. Grinblatt and Han (2005) showed that the momentum and the disposition effects are linked together, as the former can be connected to stocks with large aggregate unrealized capital gains, which have higher returns than stocks with large aggregate unrealized capital losses. Frazzini (2006) argued that the presence of a large proportion of investors exhibiting the disposition effect leads to stock price "underreaction" to news and increases return predictability. The prevalence of investors displaying the disposition effect also promotes persistence in financial asset dynamics. Birru (2015) employed investor-level data to demonstrate that, following a stock split, the disposition effect was not evident. He proposed that although the disposition effect may hinder stock prices from reflecting information, it cannot solely account for momentum. Janssen et al. (2020) examined the relationship between the disposition effect and market efficiency and found that the disposition effect measured in the gain domain has qualitatively different implications from the disposition effect measured in the loss domain.

From the theoretical perspective, the disposition effect has received four possible explanations, based on mental accounting, prospect theory, regret aversion, and self-control hypothesis (see Shefrin and Statman, 1985). Regarding prospect theory, Kahneman and Tversky (1979) assumed that investors frame their choices based on potential gains/losses relative to a fixed reference point, i.e., the purchasing price. Then, each selling decision is evaluated through an S-shaped value function that is concave in the gain domain and convex in the loss domain. The resulting differences in risk attitude should explain why investors tend to hold onto stocks at a loss and sell stocks at a gain. In the case of mental accounting (Thaler (1980), Thaler (1985)), decision-makers split different trading decisions into separate virtual accounts, applying the prospect theoretic decision rules to each, ignoring possible interactions. Hence, a trading strategy involving two assets results from two independent decisions where a gain does not "counterbalance" the negative perception of a loss of a similar amount, which explains the observed higher frequency of trading on gaining stocks. It is worth noting that the wide framing approach is "orthogonal" to the mental accounting hypothesis since it considers the aggregate portfolio performance and assumes that the interactions between each position have a fundamental role in determining the disposition effect. By contrast, mental accounting yields a narrow framing explanation of the disposition effect.

Regret theory (see, e.g., Loomes and Sugden, 1982; Fogel and Berry, 2010) postulates that investors make their choices seeking rejoice and avoiding regret. This behavior leads them to realize gains and defer losses.

Finally, the self-control hypothesis (Thaler and Shefrin, 1981) connects the disposition effect to an interpersonal conflict in investors between a rational part, the planner, and a primitive, emotional myopic agent, the doer. The inconsistency between the two would lead investors to irrational trading decisions, such as the disposition effect.

In his seminal empirical analysis of the disposition effect, Odean (1998) proposed a formula to measure it that is still used by scholars. He analyzed the trading records of 10,000 US accounts between 1987 and 1993, and found that investors tend to realize their winning stocks more frequently than their losing ones. In the same year, Weber and Camerer (1998) showed that the disposition effect is also related to the time stocks are held since, if investors are forced to open and close their position on the same day, the disposition effect vanishes.

Empirical analyses have also examined the disposition effect, but they do not offer a clear explanation of the mechanism through which this phenomenon originates from mental accounting, prospect theory, regret aversion, and self-control hypothesis. Below, we provide a concise overview of these four theoretical determinants of the disposition effect, along with a list of select applied works that have used empirical methods to test the effectiveness of these theories in accounting for this phenomenon.

2.1. Narrow framing (mental accounting) vs wide framing

Following Odean's (1998) seminal work on the disposition effect, subsequent research has focused on the narrow framing hypothesis, which assumes the validity of the mental account hypothesis by excluding the portfolio dimension and interactions between different stocks' performances. In recent years, researchers have recognized the limits of the narrow framing hypothesis and have shifted their focus to the wide framing approach, which incorporates the portfolio dimension and challenges the mental accounting paradigm. Sakaguchi et al. (2019) were among the first researchers who considered the entire portfolio balance. Specifically, Sakaguchi et al. (2019) analyzed laboratory and real market data, focusing on days when each investor sold only one asset. They found that the disposition effect was stronger when there was only one losing stock and two gaining stocks in the portfolio. On the other hand, more recently, Brettschneider et al. (2021a, 2021b) utilized the same dataset as Odean (1998) to confirm the existence of a clear disposition effect under the wide framing hypothesis, finding that the probability of realizing a loss increases with the percentage of gains in the portfolio. An et al. (2023) analyze the portfolio driven disposition effect controlling for the portfolio returns and the volatility of daily returns calculated using the 250 days prior to the purchase of the stock.

2.2. Self-control hypothesis

Grinblatt and Keloharju (2001) showed that the disposition effect occurs across several categories of investors, characterized by different degrees of self control. Hermann et al. (2019) showed that the disposition effect can also occur when a subject makes a decision on behalf of another person. This evidence challenges the self-control hypothesis as a possible driver of the disposition effect because the above categories of investors are expected to have a high degree of self-control.

2.3. Prospect theory

Several researchers have simulated the behavior of several representative prospect investors to assess the correspondence between the simulated and observed size of the disposition effect (Kahneman and Tversky (1979), Kahneman and Tversky (2013), Tversky and Kahneman (1981). However, the general findings suggest that the simulated disposition effect is weaker than the observed one, unless using extreme and unrealistic parameters for the value function (Barberis and Xiong, 2009). The evidence has prompted scholars to question the validity of prospect theory as a theoretical antecedent of the disposition effect. In particular, Barberis and Xiong (2009) demonstrated that in a multi-period model, the prospect theory is not entirely capable of predicting the ratios between realized gains and losses observed in empirical applications.

Kaustia (2010) measured the probability of selling a stock based on its performance and found that prospect theory can predict holding onto both losses and gains.

Henderson (2012) examined the disposition effect through the lens of prospect theory and found it to be consistent with the empirical results. However, for low Sharpe ratios, investors stop selling losses. Meng and Weng (2018) built on the concept of reference point adaptation and found that the ability of prospect theory to predict the disposition effect depends on how and whether investors adjust their reference point. By accounting for reference point adaptation, prospect theory improves its explanatory power of the disposition effect, revealing a history dependence in stock holding. Andrikogiannopoulou and Papakonstantinou (2020) explored dynamic risk preferences in a prospect theory framework and found supporting empirical evidence for moderate loss aversion and probability overweighting of extreme outcomes. Heimer et al. (2023) investigated the rationalization of the disposition effect using a model that incorporates probability weights and gain-loss asymmetry, such as the cumulative prospect theory.

2.4. Regret theory and mean reversion

To the best of our knowledge, only two papers in the literature attempt to explain the disposition effect using regret theory. Besides Shefrin and Statman (1985), Muermann and Volkman (2006) developed a dynamic portfolio model where investors make choices based on a prespecified utility function that incorporates a rejoice/regret parameter. They showed that such preferences can cause investors to sell gaining stocks and hold on to losing stocks. Although these two papers are interesting and original, they only link the disposition effect to regret theory on a theoretical basis. An empirical assessment based on tests using real market data has yet to be conducted.

The empirical literature has investigated a behavior strongly related to regret aversion, known as mean-reverting expectation. According to Kaustia (2010), investors tend to "sell winning stocks and hold onto losing stocks simply because they expect prior

Table 1
Descriptive statistics for italian non-professional private investors.

Dimensions	Measure	Values
Episodes	Aggregate	691,111
Episodes per investor per month	Mean	68
# of assets	Median	32
Holding time per asset (days)	Median	22.94
Account's duration (years)	Median	2.93

returns to reverse in the future.". This idea implies a disposition behavior, but the empirical evidence is mixed. Kaustia (2010) provided evidence against the mean-reversion hypothesis, finding that recent appreciation decreases selling for unrealized loss positions, contrary to the hypothesis. On the other hand, Jiao (2017) tested for the disposition effect on two groups of investors, one with and one without mean-reverting expectations about future returns. He found that only mean-reverting investors exhibit the disposition effect.

Early literature on estimating the disposition effect relied mainly on logit models, as demonstrated by Grinblatt and Keloharju (2001) and Birru (2015). However, more recent studies such as An et al. (2023), Chang et al. (2016), and Brettschneider et al. (2020, 2021a, 2021b) have employed linear probability models, which provide a direct interpretation of marginal effects and allow for robust identification of coefficients. Probability models are usually estimated using ordinary least squares (OLS) under the assumption that a linear approximation is appropriate and residuals are homoskedastic. However, in this paper, our empirical analysis involves a heterogeneous pool of nearly 4000 investors trading more than 6000 assets, which can lead to heteroskedasticity issues. Therefore, we use the weighted least squares (WLS) estimator, as proposed by Goldberger et al. (1964), which is more robust to heteroskedasticity than OLS.

Our paper seeks to partially reconcile theoretical hypotheses and applied results by amalgamating the broad and specific frameworks into an innovative approach that we term integrated framing. We first test the robustness of our dataset by applying the model by Brettschneider et al. (2021a, 2021b). Next, we introduce an augmented econometric model including the variables that account for the aggregate portfolio performance, and holding times, as well as their interactions.

3. Data and methodology

Our dataset, which is provided by an Italian security brokerage firm (see their website at https://www.directa.it), includes data on over 24 million operations executed by 4,000 Italian non-professional private investors across more than 6,000 different assets. Specifically, the period covered by the dataset spans from January 2010 to December 2018, during which the investors were continuously monitored. Each transaction in the dataset contains details on the number of bought and sold stocks, purchase and selling prices, and market prices. In Table 1, we report descriptive statistics for all the variables in our dataset. Following Brettschneider et al. (2021a, 2021b), we classify our data into trading episodes, where an episode is defined as any sale (including partial) of a security owned by any investor. We exclude short-selling trades, a common practice in the field (Brettschneider et al., 2021a, 2021b). The dataset comprises 691,111 episodes, with an average of approximately 68 episodes per investor per month. The median duration of investors' account opening is 2.93 years, with a median of 32 assets held. On average, each asset in the portfolio is held for almost 23 days (holding time).

First, we check if the results obtained using our dataset are consistent with previous findings by Brettschneider et al. (2021a, 2021b). To this end, we adopt the same regression model as in Brettschneider et al. (2021a, 2021b):

$$Y_{ijt} = \beta_0 + \beta_{CP} CP_{ijt} + \beta_{PP} PP_{kijt} + \beta_{CP,PP} CP_{ijt} \times PP_{kijt} + \epsilon \tag{1}$$

where, for any episode, Y_{ijt} is equal to 1 if stock i in account j is sold (completely or partially) at time t, and 0 otherwise. Thus, the value of Y_{ijt} fitted by the regression model (1) represents the willingness to sell the asset i at time t by investor j. The variable CP_{ijt} is another dummy that measures the *current performance* of asset i in portfolio j at time t. It is equal to 1 if at time t the market price of asset i in account j is greater than the average price at which the asset was purchased. Therefore, CP_{ijt} accounts for the propensity of selling an asset currently at a gain. We also use five dummy variables PP_{kijt}, with $k \in 1,2,4,5,6$, to measure portfolio performance, discretizing the fraction of assets in the portfolio that are at a gain. Specifically, to obtain PP_{ijt}, we compute:

$$\frac{\#(assets\ at\ gain - (asset_i | CP_i = 1))}{\#assets\ in\ the\ portfolio - 1}$$

As we may see, if asset i is at a gain, we exclude it from the formula by subtracting 1 from both numerator and denominator ($asset_i | CP_i = 1$). If asset i is at a loss, we subtract 1 only from the denominator. Then, following the sextile splitting in Brettschneider et al. (2021a, 2021b), we divide the interval $[0,1]$ in six subgroups: $[0, 0.10]$, $]0.10, 0.33]$, $]0.33, 0.50]$, $]0.50, 0.61]$, $]0.61, 0.80]$, $]0.80, 1]$ and, for $k = 1,2,4,5,6$, we set $PP_{kijt} = 1$ if PP_{ijt} belongs to the k_th bin and $PP_{kijt} = 0$ otherwise, keeping the third bin as the reference variable. Therefore, PP_{kijt} accounts for the propensity of selling an asset within each distinct portfolio performance subgroup. Finally, we consider the product $CP_{ijt} \times PP_{kijt}$, $k = 1,2,4,5,6$, i.e., we include 5 dummies to model the interactions between the willingness to sell an asset currently at a gain and the portfolio performance.

As in Brettschneider et al. (2021a, 2021b), we estimate the baseline regression model (1) as well as an analogous model where we also consider fixed effects for investors, months, and both.

To address potential heteroskedasticity issues arising from our heterogeneous sample of almost 4,000 investors trading more than 6,000 assets, we estimate model *(model 1)* using a weighted least squares (WLS) estimator. This approach is superior to the standard OLS in the case of heteroskedasticity (Goldberger, 1964, Aldrich and Nelson, 1984). Following Aldrich and Nelson (1984) we calculate weights according to the following formula:

$$w_i = \sqrt{\frac{1}{\hat{Y} \times (1 - \hat{Y})}}$$

where $\hat{Y}$ are the fitted values resulting from ordinary least squares regression. We note that when they are smaller than 0 or greater than 1, they are recomputed and forced to take value in $[0, 1]$, so that we can regard them as probabilities.

3.1. The integrated framing

To investigate the potential dependence of the disposition effect on stock performance, we augment the wide framing model (1) by including variables that account for the behavior of each asset during the time interval it is held in the portfolio. By doing so, we present, for the first time in literature, an integrated framework that unites the empirical evidence on the disposition effect with its possible theoretical determinants as identified by the regret and prospect theories. Specifically, in line with Kaustia (2010) and Jiao (2017), we assume that the holding history of the assets influences investors. Accordingly, we augment the wide framing approach by including a new variable, *past asset performance* (AP_{ijt}), which measures if a stock in the portfolio has been at a gain/loss for the majority of the time. In particular, we calculate the variable AP as the ratio between the number of days on which stock i in account j was at a gain over the total number of days on which the stock was held in the portfolio. A negative coefficient suggests that the propensity of selling the stock is inversely proportional to the (relative) number of days on which the stock is at a gain, in line with regret in selling an “often winner” stock.

Following the prospect theory, we argue that the volatility of the stocks, as it measures their risk and interacts with the curvature of the value function, may be a determinant of the disposition effect. An et al. (2023) in their wide framing approach include the market volatility, computed using the 250 days prior to the purchase of the stock. Accordingly to their approach, we include a new variable, *perceived asset risk* (PR_{ijt}), which captures the volatility of the stocks over the time interval in which they are held in the portfolio. We calculate PR as the standard deviation of the returns of the stock i over all the days on which the stock is held in account j. Since we consider only the days on which the stocks remain in the portfolios, PR is a measure of the risk that investors perceive based on their own experience. In this way we improve An et al. (2023) approach by including a variable that accounts for an investor and asset’s specific measure instead than focusing on aggregate market volatility. If the associated regression coefficient is positive, the probability of selling the stocks increases with the perceived risk, as implied by the curvature of the value function postulated by the prospect theory. We incorporate *(*past asset performance) and *(*perceived asset risk) into our regression model as follows:

$$\begin{aligned} Y_{ijt} = {} & \beta_0 + \beta_{CP} CP_{ijt} + \beta_{PP} PP_{kijt} + \beta_{CP,PP} CP_{ijt} \times PP_{kijt} + \beta_{AP} AP_{ijt} \\ & + \beta_{PR} PR_{ijt} + \beta_{CP,AP} CP_{ijt} \times AP_{ijt} + \beta_{CP,PR} CP_{ijt} \times PR_{ijt} + \epsilon_{ijt} \end{aligned} \tag{2}$$

It is important to note that our model includes terms that model the interactions between each of the variables *AP* and *PR* and the variable *CP*, which indicates if the stock is currently at a gain or loss. Indeed, an *integrated* approach to the disposition effect must consider the interplay between the (narrow framing) variables *AP* and *PR* and the individual’s willingness to sell gaining/losing assets. This is because the disposition effect is driven by the asymmetrical propensity to sell a gaining stock compared to a losing one. Therefore, an integrated approach that incorporates both of these interactions is essential for a comprehensive investigation of the disposition effect.

Descriptive statistics for the variables used in our model are provided in Table 2.

4. Results

4.1. Comparison with the wide framing literature

The first step of our empirical analysis involves validating the consistency of the results obtained from applying the baseline regression (1) with the findings of the benchmark study by Brettschneider et al. (2021a, 2021b). Thus, we compare the estimated parameters’ signs and sizes with the results we expect based on our wide framing approach. This step aims to enhance the robustness of the conclusions we draw from our integrated framing procedure. The results we present in the following tables are obtained using the WLS estimator. Results computed using the standard OLS are available in the paper’s appendix.

The results of the baseline regression (1) without fixed effects, which we report in Table 3, show evidence of the existence of the disposition effect. Indeed, the coefficient of CP is positive and highly significant. We may also see the significance of the portfolio effect (PP_k), which has a negative and significant coefficient only for portfolios at a gain, as revealed by the interaction terms’

Table 2
Descriptive statistics.

Vars	mean	stand. dev.	median	5%	95%
Y	0.02814	0.16538	0	0	0
CP	0.41489	0.49270	0	0	1
PP_1	0.15442	0.36135	0	0	1
PP_2	0.22120	0.41506	0	0	1
PP_3	0.28818	0.45291	0	0	1
PP_4	0.09503	0.29326	0	0	1
PP_5	0.15998	0.36659	0	0	1
PP_6	0.08116	0.27309	0	0	0
AP	0.37863	0.36959	0.265151	0.000000	0.9885
PR	0.00641	0.00993	0.003479	0.000829	0.0209
$CP \times AP$	0.29257	0.39082	0.000000	0.000000	0.9885
$CP \times PR$	0.00258	0.00725	0.000000	0.000000	0.0125

Table 3
Baseline model (1), WLS estimation without fixed effects. * and *** denote significance at the 90% and 99% respectively; SE = Standard Error; AIC = −22029287.

Vars	β	SE
(intercept)	0.01684246***	0.00006940
CP	0.03401268***	0.00012993
PP_1	−0.00298577***	0.00010574
PP_2	−0.00195598***	0.00009825
PP_4	−0.00087162***	0.00015020
PP_5	−0.00145901***	0.00012952
PP_6	−0.00028318*	0.00017153
$CP \times PP_1$	0.02351409***	0.00026050
$CP \times PP_2$	0.01330027***	0.00021691
$CP \times PP_4$	−0.01138823***	0.00024359
$CP \times PP_5$	−0.01515425***	0.00020288
$CP \times PP_6$	−0.02713138***	0.00024777

Table 4
Baseline model (1) with fixed effect for investors, WLS estimation. ** and *** denote significance at the 95% and 99% respectively; SE = Standard Error; AIC = −26312132.

Vars	β	SE
CP	0.0283427***	0.0007729
PP_1	−0.0037349***	0.0002496
PP_2	−0.0012126***	0.0001854
PP_4	0.0012648***	0.0001977
PP_5	0.0012137***	0.0002305
PP_6	−0.0006677**	0.0002770
$CP \times PP_1$	0.0163854***	0.0011540
$CP \times PP_2$	0.0119722***	0.0009121
$CP \times PP_4$	−0.0093754***	0.0006638
$CP \times PP_5$	−0.0129261***	0.0008331
$CP \times PP_6$	−0.0208601***	0.0008709

coefficients ($CP \times PP_k$). In line with Brettschneider et al. (2021a, 2021b), these interaction effects are more pronounced in the more extreme cases.

Specifically, the estimated coefficients of model (1) exhibit the same sign and significance as those reported in Table 3 of Brettschneider et al. (2021a, 2021b).

Our investigation revealed that incorporating fixed effects for investors, months, and both investors and months did not substantially alter the results, and remained consistent. However, based on the penalized log-likelihood (Akaike criterion), we found that the model that considers only fixed effects for individuals is the most informative. Thus, we report only the results obtained for the fixed effect for investors in this paper to save space.

Table 5
Model (2), WLS estimation. ** and *** denote significance at the 95% and 99% respectively; SE = Standard Error; AIC = −27738486.

Vars	β	SE
CP	0.0832205***	0.0021008
PP_1	−0.0030118***	0.0002356
PP_2	−0.0006392***	0.0002058
PP_4	0.0007287***	0.0001955
PP_5	0.0004233**	0.0002116
PP_6	−0.0013440***	0.0003581
$CP \times PP_1$	0.0087144***	0.0008266
$CP \times PP_2$	0.0046054***	0.0005799
$CP \times PP_4$	−0.0028214***	0.0004222
$CP \times PP_5$	−0.0033844***	0.0005170
$CP \times PP_6$	−0.0076368***	0.0006594
AP	0.0059718***	0.0003686
PR	0.2344416***	0.0168379
$CP \times AP$	−0.0881973***	0.0022053
$CP \times PR$	0.6204865***	0.0723811

Table 4 presents the results of the standard WLS estimation with investor fixed effects. All of the estimated coefficients are highly significant. The signs and magnitudes of the coefficients of the dummy variables PP_k indicate that the probability of realizing a stock at a gain are consistent with Brettschneider et al.'s findings (2021a).

4.2. The integrated framing

Table 5 shows the results of the proposed integrated framing approach, obtained using the WLS estimator. The estimates underscore the significance of considering both portfolio performance and assets' idiosyncratic risk, confirming that the disposition effect is driven by both a wide and a narrow mechanism. Specifically, as the portfolio performance dimension remains statistically significant, the coefficient of the interaction term $CP \times AP$ is negative and statistically significant, indicating that the probability of selling a stock currently at a gain decreases as the number of days on which the stock has been gaining increases. Hence, past performance mitigate the tendency of investors of getting rid of currently gaining stocks.

From a regret theory perspective, investors fear the future regret of having sold one of the stocks that perform better. Therefore, the current asset performance (CP) acts as a discriminant variable based on which investors form their regret/rejoice expectations having observed the past performance of the stocks (note that the coefficient of AP is positive and significant). This result is consistent with practitioners' warning "don't fall in love with a stock.". It is essential to note that the coefficient of AP is positive and significant, further supporting the influence of past performance on investment decisions. Our findings reveal that investors exhibit a tendency to retain stocks currently experiencing gains and boasting positive historical performance. As a result, past performance emerges as a mitigating factor for the disposition effect, providing additional evidence in support of the narrow framing dimension. The tendency to sell gaining stocks is contingent on specific asset characteristics, encompassing both their present and past performance. This outcome underscores the importance of maintaining a narrow approach when analyzing the disposition effect. Specifically, the willingness to divest a losing stock is heightened when its past performance was positive. This observation possibly aligns also with the regret aversion hypothesis, suggesting that investors seek to evade the possibility of regretting potential future losses by divesting assets that, despite a positive historical performance, are presently in decline. Similarly, in a bid to forestall the regret of missing out on future gains, investors prefer to retain assets that have demonstrated past success and are currently in a profitable position.

Furthermore, our analysis reveals that the willingness to sell an asset increases with the perceived risk associated with it (the estimated coefficient of PR is positive and statistically significant). This result suggests that the average investor is risk-averse, providing support for the prospect theory. The inclusion of variables related to idiosyncratic risk does not alter the conclusions regarding the other *(wide framing)* determinants of the disposition effect, as the PP_k variables continue to be significant and consistent with Brettschneider et al.'s findings (2021a).

Finally, we highlight that the Akaike Information Criterion (AIC) value for model (2) is significantly lower than that of the baseline model (1). This finding indicates that our integrated approach has a better goodness-of-fit than the standard model, further emphasizing the significance of combining both wide and narrow framing approaches for empirical studies on the disposition effect.

Our study aligns with a significant portion of the theoretical literature focusing on the behavior of financial investors. Our analysis suggests that the positive effect of AP (the past performance of stocks) impacts the willingness to sell them. Indeed, the estimated positive effect of AP indicates that investors are more likely to sell stocks that have been mostly at a gain during the holding period. Additionally, our findings suggest a value function shape that is in line with prospect theory, as the estimated narrow framing parameters of model (2) (see Table 5) imply higher risk aversion in the gain domain.

First, the positive and statistically significant coefficient of PR reveals that the perceived volatility of a stock influences the propensity to sell it. Furthermore, the coefficient measuring the interaction between PR and the willingness to sell stocks at a gain CP is positive, significant, and higher than the coefficient measuring the propensity to sell stocks without the interaction term CP.

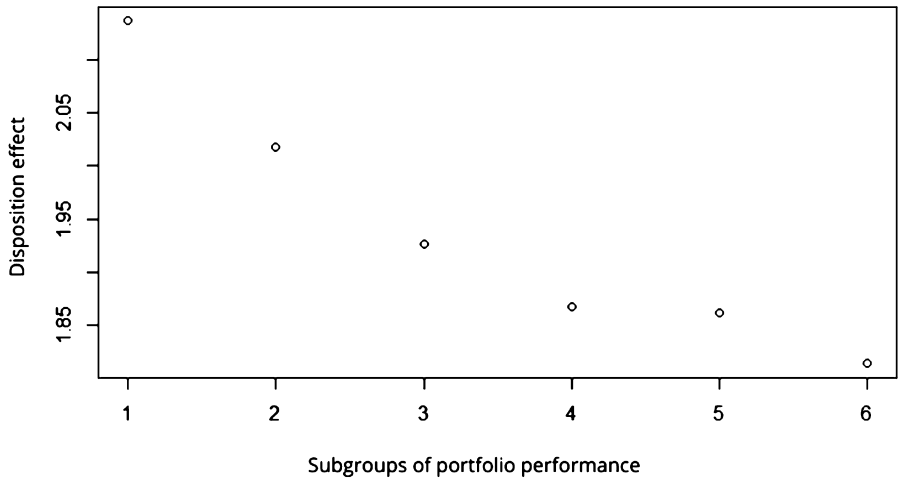

Fig. 1. Disposition effect computed as the ratio between propensity to realize a gain and propensity to realize a loss (Odean, 1998). Both propensities are derived from the coefficients presented in Table 5, considering individual-specific fixed effects.

Our study's results are in line with the regret theory as we expect that investors, in a bid to avoid future regret, are less inclined to sell stocks that currently show a profit and have a positive holding history compared to those currently in a loss. Our estimates support this expectation, as the coefficient of AP^*CP is negative, while the coefficient of AP is positive, and both are statistically significant.

Furthermore, the inclusion of the new variables AP and PR in our analysis allows us to obtain a smaller AIC coefficient than the wide framing approach of Brettschneider et al. (2021a, 2021b), as shown in Tables 4 and 5. This indicates that our integrated framework provides a better estimation of the disposition effect than the wide framing benchmark.

Our integrated framing approach allows us to capture the mechanism through which investors' risk aversion and stocks' holding history simultaneously affect their willingness to sell. Equation (2) defines the performance of an asset using three measures: AP, which measures the *(past asset performance)* during the entire time interval in which the asset is held, CP, which measures the *current asset performance* at the time of sale, and PR, which measures the *perceived asset risk*.

Moreover the investors' willingness to sell a stock at a gain, as estimated by our integrated framing approach, is higher than the disposition effect obtained using the wide framing benchmark (1), when the controls from model (2) are "unobserved". Furthermore, the significance of interactions between past asset performance (AP) and current performance (CP) and between perceived risk (PR) and current performance shows that current performance increases the willingness to sell high-volatility stocks while decreasing the willingness to sell high-performing stocks.

It is noteworthy that the effect related to asset performance is the dominant factor. Indeed, the net idiosyncratic effect on the willingness to sell a stock, which is the weighted sum of the coefficients $\beta_{AP,CP}$ and $\beta_{PR,CP}$ of $CP \times AP$ and $CP \times PR$ (weighted by the average values of $CP \times AP = 0.29257$ and $CP \times PR = 0.00258$), is negative and statistically significant.

Fig. 1 illustrate variations in the disposition effect across the six distinct subgroups used in our analysis. In line with Brettschneider et al. (2021a, 2021b), we find an inverse relation between disposition effect and portfolio performance, lending further support to our hypothesis that the disposition effect can be moderated through strategic portfolio composition. What's particularly noteworthy is that this negative relation is confirmed also for the sixth subgroup (where stocks at a gain are more than 80%), deviating from the U-shaped pattern found in Brettschneider et al. (2021a, 2021b). We argue that investors achieving higher portfolio performance appear to experience less regret when realizing their losses, indicating a higher level of rationality. They display a greater propensity to "cut their losses and let their profits run" underscoring a potential strong link between regret theory and the disposition effect, encouraging us to advocate for further research aimed at investigate the theoretical and empirical relationship between these two concepts.

To the best of our knowledge, this study provides the first empirical evidence showing the disposition effect's probable alignment with regret and prospect theories, two of the most widely used theoretical approaches in behavioral finance.

Indeed, we show that investors tend to hold on to stocks at a gain if their past performance was positive, while they sell stocks at a loss if their past performance was positive. Holding on to losses and getting rid of gains seems due to past performance and not to current performance alone, giving more clarity to the disposition effect as found in narrow framing studies. This finding supports the assumption that investors form their expectations about future returns based on a simple projection of the realized asset performance, as proposed by Jegadeesh and Titman (1993), and their decisions are driven by the regret of committing a mistake in selling or not selling a stock.

Moreover, our results are consistent with previous studies that show that investors decide whether to hold a stock based on its previous history. Finally, in line with prospect theory, we demonstrate that investors' willingness to sell increases with the perceived volatility, particularly for stocks at a gain.

5. Conclusions

In this paper, we propose an integrated framing approach that combines the wide and narrow framing approaches to model the willingness to sell a stock, considering both the portfolio performances and the past asset performance and perceived asset risk. Such an approach allows us to better capture the underlying mechanisms driving investors' decisions.

Our econometric procedure aligns with and potentially reconciles the possible theoretical antecedents of the disposition effect: mental accounting, prospect theory, regret aversion and self selection. Specifically, our integrated approach provides a reliable explanation of the occurrence of the disposition effect possibily based on prospect theory without requiring us to assume unrealistic parameters for the investors' value function, as implied by the narrow framing literature.

Moreover, our study builds upon prior research by concurrently examining both asset volatility and its interaction with the disposition effect. This approach provides insight into the potential relationship between prospect theory and the disposition effect. Additionally, we delve into the impact of regret on the inclination to sell by scrutinizing the estimated coefficients of both the term accounting for past asset performance and the term measuring the interaction between past and current asset performance. This unique approach constitutes a novel contribution to the existing literature on the disposition effect.

It is worth noting that the empirical literature on the disposition effect has often utilized the dataset introduced in Odean's seminal work (1998), which covers the years from 1987 to 1993. However, during that period, trading decisions were predominantly orchestrated by intermediaries, emphasizing a limited array of financial instruments, and technology was significantly different from what is used today. The prevalence of private investors with direct market access was lower, markets were less developed with fewer financial assets, and accessing financial information was comparatively more challenging. Hence, an additional contribution of our study lies in the analysis of a novel dataset spanning from 2010 to 2018, incorporating over 24 million transactions. We have tested this dataset using the model proposed by Brettschneider et al. (2021a, 2021b) and have obtained results that are consistent with this benchmark. Thus, we can conclude that our dataset provides a reliable and up-to-date alternative for exploring the disposition effect empirically.

Furthermore, our study reveals that the perceived asset risk, which is measured as the volatility of an asset over the time interval during which it remains in the portfolio, is positively related to the willingness to sell it, especially when it is trading at a gain. This finding is consistent with the risk-aversion expectations implied by the prospect theory. Moreover, the effect of asset volatility on the propensity to sell is more pronounced for stocks at a gain, which aligns with the shape of the value function postulated by the prospect theory.

In addition, we find that among the stocks with positive past performance, investors tend to hold on to those that are currently at a gain. We observe that investors' inclination to sell gaining stocks is influenced not only by current performance but also by past performance. This provides additional evidence of the significance of an asset's individual characteristics, specifically the narrow framing dimension, in the analysis of investment decisions. Conversely, the willingness to sell a losing stock is higher if its past performance was positive. Hence, when considering investors' holding on to losses, past performance is likely a crucial variable to consider. This outcome likely aligns with regret aversion, wherein investors seek to sidestep the potential regret associated with future losses by divesting assets that, despite a positive historical performance, are presently in decline. Similarly, to avert the regret of foregone future gains, they opt not to sell assets that have demonstrated past success and are currently yielding profits.

Interestingly, our findings reveal that the disposition effect is not solely driven by the current performance of stocks, but also by their performance over the time interval during which they remain in the portfolio. Specifically, past asset performance reduces the asymmetry in the willingness to sell at a loss or gain, modulating the disposition effect. This result is consistent with Jegadeesh and Titman's (1993) study and, more generally, with the theory of rational investors.

Finally, we demonstrate an inverse relationship between the disposition effect and portfolio performance, bolstering the evidence we have presented and indicating a plausible link between the disposition effect, loss aversion, and the regret theory. These findings cohesively align with the existing literature on the subject.

Through our integrated framing approach, we present empirical evidence that supports the conceivable connection between the disposition effect and both regret and prospect theories. The theoretical examination of these relationships is deferred to future research.

In essence, our findings underscore the significance of embracing both wide and narrow framing mechanisms, along with exploring their interplays. These results additionally affirm the impact of idiosyncratic risk on investment decisions, offering valuable insights into the intricate factors shaping investment behavior.

Declaration of competing interest

As the corresponding author of the paper, I confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Data availability

Data will be made available on request.

Appendix A

See Table 6.

Table 6
Baseline model (1), OLS estimation. *** denote significance at the 99% level; SE = Standard Error.

Vars	β	SE
(intercept)	0.01684246***	0.00008074
CP	0.03401268***	0.00012550
PP_1	−0.00298577***	0.00012660
PP_2	−0.00195598***	0.00011613
PP_4	−0.00087162***	0.00017661
PP_5	−0.00145901***	0.00015319
PP_6	−0.00028318	0.00020026
$CP \times PP_1$	0.02351409***	0.00023187
$CP \times PP_2$	0.01330027***	0.00020036
$CP \times PP_4$	−0.01138823***	0.00024953
$CP \times PP_5$	−0.01515425***	0.00021045
$CP \times PP_6$	−0.02713138***	0.00026851

See Table 7.

Table 7
Baseline model (1) with fixed effects for investors, OLS estimation. *** denote significance at the 99% level; SE = Standard Error.

Vars	β	SE
CP	0.0356929***	0.0010215
PP_1	−0.0113371***	0.0005678
PP_2	−0.0017649***	0.0003968
PP_4	0.0037295***	0.0003715
PP_5	0.0027207***	0.0004888
PP_6	−0.0048207***	0.0005759
$CP \times PP_1$	0.0221821***	0.0014560
$CP \times PP_2$	0.0116690***	0.0010266
$CP \times PP_4$	−0.0118872***	0.0008244
$CP \times PP_5$	−0.0147822***	0.0010219
$CP \times PP_6$	−0.0225534***	0.0011216

See Table 8.

Table 8
Model (2), OLS estimation. *** denote significance at the 99% level; SE = Standard Error.

Vars	β	SE
CP	0.10384***	0.002476
PP_1	−0.00897***	0.0005572
PP_2	−0.00004	0.0003979
PP_4	0.00200***	0.0003520
PP_5	0.00008	0.0004656
PP_6	−0.00721***	0.0005695
$CP \times PP_1$	0.01372***	0.001457
$CP \times PP_2$	0.00690***	0.0009833
$CP \times PP_4$	−0.00800***	0.0007545
$CP \times PP_5$	−0.00935***	0.0009853
$CP \times PP_6$	−0.01745***	0.001150
AP	0.01298***	0.0007050
PR	0.26236***	0.028200
$CP \times AP$	−0.11859***	0.002714
$CP \times PR$	1.02825***	0.100400

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